Part 3 – Detailed Project Description

1. Project title

Evaluation of the Healthy Start Voucher Scheme in UK: a natural experiment using the Growing Up in Scotland record linkage study and the Infant Feeding Survey

2. Background

2.1 Existing research

Poor nutrition in pregnancy and the early years of life have impacts on health. The developmental model of the origins of chronic disease proposes the causal influence of under nutrition in utero on coronary heart disease and stroke in adult life [1]. Maternal nutrition strongly influences child nutrition which in turn tracks to adult eating patterns [2-4]. As poor nutrition is associated with lower socio-economic status [5], these impacts also may perpetuate health inequalities. An intervention that modifies both maternal and infant diet thus has the potential to improve the health of the infant, and for these health gains to track into childhood and adulthood, thus reducing health inequalities. There is a need to evaluate nutritional interventions in pregnancy and childhood to robustly determine which are effective and cost-effective.

The Welfare Food Scheme (WFS) started in 1940 as a universal benefit to ensure expectant and new mothers had a healthy diet during rationing. It subsequently became targeted to lower income mothers and families. It provided tokens that could be exchanged for liquid and formula milk and vitamins to expectant and nursing mothers, and to children under 5. Healthy Start Vouchers (HSV), a means tested voucher scheme, was introduced UK wide in 2006 as a replacement to the WFS. It has the potential to improve the health of low-income families who have poorer nutrition than more affluent families. The purpose of the HSV scheme is to provide low-income pregnant women, new mothers and children under four years with access to appropriate nutrition [6].

The effectiveness and cost-effectiveness of the HSV has not yet been shown. A previous small (N=336) comparison of HSV to the WFS found that mothers eligible for HSV had higher daily intake of iron, calcium, folate and vitamin C than mothers eligible for WFS [7]. Three months postpartum, the HSV mothers again reported higher iron, calcium, folate, and vitamin C intake, as well as higher consumption of fruit and vegetables [8]. A mixed methods study of practitioners and low income mothers found that recipients valued the vouchers, but there were substantial barriers to access including low levels of awareness of the HSV among both mothers and practitioners and uncertainty about the eligibility criteria among health professionals [9]. A recent report on the operational aspects of the HSV concluded a comparative study is needed to assess the effectiveness and cost-effectiveness of the Healthy Start scheme [10]. The report addressed issues of eligibility and uptake of HSV. To determine the effectiveness and cost-effectiveness of population based feeding programmes, such interventions need to be evaluated in larger studies using a wider range of outcomes with longer term follow-up and methods appropriate for deriving causal inferences from observational data.

2.2 Risks and benefits

The benefits of this research are Healthy Start Vouchers have the potential to improve the health of low-income families who are likely to have poorer nutrition than more affluent families, and thereby reduce health inequalities. It is estimated that around 33,745 children and 10,551 women per

annum across Scotland [11] are entitled to HSV and over 423,000 households in the UK claim HSV [12].

This evaluation of the HSV, has a focus on outcomes in pregnancy, early infancy and late infancy, with the potential to follow infants into adulthood through routinely collected data. The proposed study design utilises a multiple analytical approach in line with MRC guidance for the evaluation of natural experiments [13]. All outcomes are health-related and we will assess the cost-effectiveness of the vouchers as well as a process measure to assess the up-take.

The evaluation of the effect of a means tested voucher scheme can inform policy aiming to change behaviour, improve health outcomes and reduce health inequalities. It will inform public health decision makers as to the benefits of vouchers for milk, fruit and vegetable intake during pregnancy and the post-natal/infancy period. It will also provide information on the characteristics of participants and non-participants and the reasons why women do and do not participate so that if the vouchers are shown to be effective in improving nutrition and other health outcomes, take-up can be improved.

Unless such schemes are rigorously evaluated there is a risk that resources will be wasted on ineffective interventions, or that opportunities to improve the design and administration of potentially valuable interventions are missed. By using existing survey data linked to routinely collected administrative data, in addition to primary qualitative data gathering, we offer an efficient, robust approach to estimating effectiveness and cost-effectiveness, as well as providing insights into the process of claiming the vouchers.

2.3 Rationale for current study

Health improvement and the reduction of health inequalities in the early years is one of the strategic objectives of the Scottish Government [14], as well as a focus of UK [15] and WHO policies. There is a need to evaluate interventions in pregnancy and childhood, in particular nutrition of pregnant women and their children. Currently Healthy Start Vouchers are means tested but there has been a call from the Chief Medical Officer (UK) to make the vitamin component of the scheme a universal benefit. NICE are reviewing the evidence to consider whether it would be cost effective for all children to receive drops or tablets containing vitamins A, C and D [15].

In 2002 it was estimated that it would cost the Exchequer £147m per annum to fund the HSV scheme [16]. In 2013-2014, £93m was paid to retailers as reimbursement for vouchers [12]. This represents a substantial investment when the UK Government is currently reducing the cost of the Welfare bill. Eight years after the introduction of the scheme, despite some research indicating possible benefits, its effectiveness and cost-effectiveness are still unclear.

This researcher-led call (13/164) for studies using pre-existing data and linked data is an ideal opportunity to use two high quality surveys, representative of the Scottish population (Growing up in Scotland - GUS) and the UK population (Infant Feeding Survey (IFS) 2010), to evaluate the HSV scheme and thereby examine potential improvement in nutrition related outcomes for low-income mothers and their children. There is a need for an evaluation of the HSV that extends previous analysis to the examination of outcomes and assessing the cost effectiveness of the HSV. A scoping review on approaches to monitoring and evaluating the scheme identified a number of outcomes and data sources for monitoring uptake and potential benefits [17]. However, the review identified difficulties in undertaking a comprehensive evaluation. One reason the scheme has not been evaluated on a large scale is the difficulty of identifying an appropriate comparison group. As the HSV is means-tested it is not clear what an appropriate comparison group is; it would not be appropriate to compare HSV recipients with non-recipients as they are a very different group in terms of socio-economic characteristics, with very different health behaviours and outcomes. One potential appropriate comparison group is those women who are eligible for HSV but do not claim

the vouchers. A second comparison group is low income women who just miss out on eligibility for HSV due to not being eligible for the means tested benefits due to slightly increased income levels. GUS offers three comparisons: recipients (group 1) and eligible non-recipients (group 2); recipients and women who are just outside the margin of eligibility on grounds of income or age (group 3); and combining groups 1 and 2 and comparing with group 3. The IFS offers one comparison group: recipients (group 1) and eligible non-recipients (group 2). Both surveys contain a range of outcome measures to evaluate HSV.

3. Research objectives

The aim is to evaluate the Healthy Start Voucher scheme in relation to the extent to which HSV improves the nutrition of pregnant women and the health outcomes of their infants.

There are six objectives to investigate:

1) The effectiveness of the HSV in relation to vitamin use in pregnancy (HSV aim 1), and breast feeding initiation and duration (HSV aim 3).

2) The effectiveness of the HSV in relation to infant and child weight and body size; child morbidity; infant and child feeding; and maternal health.

3) How findings differ between different populations.

4) To establish actual voucher usage

5) To establish the cost effectiveness of the HSV.

6) To determine reasons for uptake and non-uptake of the HSV.

4. Research design

The evaluation will take a mixed methods, natural experiment approach to investigate the effectiveness of the HSV in pregnant and new mothers, as well as their children. This is an analysis of existing data, incorporating a cost effectiveness analysis and enhanced with an embedded qualitative study. Thus, there are three parts to this evaluation: 1) secondary analysis of two existing data sets, including linking one of the existing data sets to routinely collected health data (objectives 1, 2, 3); 2) cost effectiveness analysis to assess the cost effectiveness (objective 4); and 3) a qualitative interview study of mothers (objective 5).

As the intervention is not controlled by the researchers, we will use multiple exposed and unexposed groups to assess the effectiveness of the Healthy Start Voucher scheme, in line with the MRC guidelines for evaluation of natural experiments. HSV is not a randomly allocated intervention so it is difficult to have complete control for confounding; there may be factors associated with receiving HSV and the outcomes that need to be taken into account. The use of multiple comparison/unexposed groups helps in the assessment of sources of bias.

An issue identified from a scoping study [17] of evaluating the Healthy Start Vouchers was the lack of obvious control group. We propose 3 control groups. The use of multiple comparison/unexposed groups gives multiple perspectives about sources of bias and so an assessment of the bias will be allowed. The comparisons we will use to assess effectiveness are:

1. Exposed (Group 1) vs eligible but not exposed (Group 2)
The exposed group are those who are eligible and claim HSV.

Eligible but not exposed are those who are eligible for HSV but do not claim them. There will be two control groups:
a. women (and children) with low incomes and in receipt of the qualifying means tested benefits but not claiming HSV.
b. women (and children) aged under 18 when pregnant but not claiming HSV.

2. Exposed (Group 1) vs nearly eligible (Groups 3a and 3b)
The exposed group are those who are eligible and claim HSV.
Nearly eligible are those who just miss the eligibility criteria for HSV. There will be two control groups based on income and age:
a. Women (and children) with low incomes but not in receipt of the qualifying means tested benefits
b. Women (and children) aged 18, 19, 20, 21 when pregnant, to compare with those aged under 18.

3. Eligible (Groups 1 and 2) vs nearly eligible (Group 3a and 3b)
All those eligible for HSV, regardless of uptake.
Nearly eligible are those who just miss the eligibility criteria for HSV. There will be two control groups based on income and age:
a. Women (and children) with low incomes but not in receipt of the qualifying means tested benefits
b. Women (and children) aged 18, 19, 20, 21 when pregnant, to compare with those aged under 18.

We will take a multiple analytical approach: propensity matching of recipients (group 1) and eligible non-recipients (group 2); regression discontinuity, comparing group 1 with women who are just outside the margin of eligibility on grounds of income or age (group 3) and an intention to treat analysis, again using a regression discontinuity approach but comparing groups 1 and 2 with group 3. Using this combination of methods will allow control for both observed and unobserved confounders. In addition the combination of methods will allow comparison of each method with their associated biases and therefore increase robustness of the results.

Propensity score matching is a technique used to limit the bias due to confounding in an observational study. The matching accounts for variables that are associated with receiving the intervention or control and therefore allows the estimation of the effect of the intervention. In regression discontinuity designs, participants are assigned to an intervention or control based on a cut-off value of an assignment variable. Even though there is no random assignment, the regression discontinuity design has comparable internal validity to randomised controlled trial designs [18].

The main comparison of interest is between exposed (Group 1) vs eligible but not exposed (Group 2) and we will use the significance of this to determine if there is any effect of HSV. This is a direct comparison of similar groups intended to be recipients of this targeted intervention and is the basis for the power calculation described in section 11 Proposed sample size. The other two comparisons will determine our confidence in the results. The directions, sizes and significance of the effects will be indicative of the confidence in the effect of HSV. If the other 2 comparisons are in the same direction, significant and of the same magnitude then we will have the most confidence that there is an effect of HSV. We will have reduced confidence if they are in the same direction but vary in size and/or significance and least confidence if the effects are in different directions, and significantly different from one another.

Secondary analysis of existing data
We will conduct secondary analysis of two existing data sets. The first is the Growing up in Scotland (GUS) Birth Cohort 2 study [19]. It is a representative sample of Scottish births. We will use data from sweep 1 and sweep 2. Data collection for sweep 1 was carried out in 2011 when the children were 10 months old. Data collection for sweep 2 was carried out in 2013 when the children were 3 years old. We will link the GUS survey data to health visitor reports and hospital admissions data. The second data set is the Infant Feeding Study 2010 (IFS) [11]. It is a representative sample of births in the UK registered during August and October 2010. The socioeconomic data from GUS are more detailed and contain information to identify all three comparison groups, allowing a fuller

evaluation. The data from IFS are from a larger sample and covers the whole of the UK. IFS does not allow for multiple comparison groups, only the comparison between recipients of HSV (group 1) and eligible non-recipients (group 2). Using the IFS will allow for data analysis to commence as soon as the project starts as the data are readily available at the UK Data Service.

There is consent from 91% of participants in GUS to link their survey responses to obstetric records (SMR02), child hospitalisations (SMR01), A&E attendance, child immunisation records, child health surveillance records and dental inspection records. These linked data will then be available at the end of this study for other approved researchers to use via eDRIS (http://www.isdscotland.org/Products-and-Services/EDRIS/) and the Farr Institute (http://www.farrinstitute.org/centre/Scotland/3_About.html). In addition there is the potential for longer follow-up of GUS participants into later childhood and adolescence. There is funding from Scottish Government to interview GUS participants in 2015 when children are aged 5. Appendix 1 is a diagrammatic representation of the existing datasets and how they link together as a cohort (GUS sweeps) and to routinely collected data. As the participants in GUS have already consented to linkage of their data, the comparison groups identified above can be followed prospectively to assess long term effects on health inequalities. [Note we are not proposing to carry out long term follow-up analysis in this piece of research but envisage the linked and follow-up data being available for other researchers to use].

Economic evaluation to assess the cost effectiveness of HSV

The economic evaluation will be integral to the main natural experiment. As economic evaluations in population health using observation data from natural experiments are a relatively new methodology and subject to the inherent biases that affect observation data this economic evaluation will follow recent guidance [13, 20], economic methods guidance [21-24] and draw on evidence from economic evaluations carried out in similar early years contexts. In addition, guidance will be sought from previous studies incorporating economics into natural experiments in education and microeconomics [25-27] including a recent review on health economic evaluations and observational data [28].

The economic evaluation will comprise an incremental cost-effectiveness analysis and will be based around relating the incremental costs of the intervention with any incremental observed outcomes of the scheme (changes in the primary and secondary outcomes). The cost of the intervention will include the cost of the healthy start vouchers along with the costs/cost savings arising from any resulting resource impacts in service utilization identified from the two surveys. A decision analytic model will be developed, based on the results of the natural experiment combined with evidence from a systematic review of the literature, to relate vitamin use and rates of breast feeding initiation changes (and any secondary outcomes affected by the HSV) to long term cost and health outcomes.

Qualitative interview study

Research to understand the processes involved in the take-up or non take-up of HSV, and how the vouchers are used, will require the collection of additional qualitative data. This part of the study is not a stand-alone component but will inform the evaluation. It will be carried out at the same time as the secondary analysis so any findings about take-up can help inform the propensity score matching [29].

We propose to carry out 40 in-depth interviews. We propose 10 from each of the following groups:

a) GUS mothers who received HSV
b) GUS mothers eligible for HSV but who did not claim
c) Mothers who currently receive HSV
d) Mothers who are currently eligible for HSV but who do not claim.

The interviews will be semi-structured, face to face, approximately an hour in length and cover a range of topics, including: what mothers know about the scheme; how they found out about it; reservations about using it and, if relevant, main reasons for not using it. If they are using/ have used the scheme we will ask about: when they started using it; who knows they are using it; perceived extra monetary benefits; how conscious they are of extra money; and how they use this extra money.

5. Study population

The population is all women eligible for Healthy Start Vouchers.
That is: pregnant women and families with children under four with low incomes or in receipt of certain means tested benefits; and all pregnant women under 18 and all mothers under 18.

The Growing up in Scotland study is a stratified cluster random sample of the whole of Scotland and is available from the UK Data Service. Children were recruited to the second Birth Cohort in 2011 when they were about 10 months old. It has a sample size of 6127, with 1350 (22%) identified as claiming HSV and 2336 (38%) identified as eligible but not claiming.

The Infant Feeding Survey (IFS) is a random sample of births in the UK from August to October 2010. There are three stages of data collection. At stage 1 (infant 6 weeks old) the sample size is 15,724; at stage 2 (infant 4-6 months old) the sample size is 12,565; at stage 3 (infant 8-10 months old) the sample size is 10,768. At stage 3, the available sample sizes are: 2369 (15%) identified as claiming HSV and 646 (6%) identified as eligible but not claiming.

IFS is available from the UK Data Service and provides UK wide data. It collects a wide range of detailed infant feeding patterns but does not have the range of other secondary outcomes available from the linked GUS data. The use of both complementary data sets will show the likely generalisability of the findings from GUS to the whole of the UK.

6. Socioeconomic position and inequalities

The HSV intervention is targeted at families on low incomes and young mothers. Therefore the intervention is designed to reduce health inequalities between these and other groups. Our evaluation of HSV will be able to gauge whether this has been successful in reducing inequalities. We will assess the impact on health inequalities by area deprivation, family income, social class, maternal education and marital status.

7. Planned interventions

The intervention being evaluated is the Healthy Start Voucher Scheme. There are four main aims of the scheme: to improve the nutrition of pregnant women; to increase fruit and vegetable intake; to initiate and maintain breastfeeding; and to introduce foods in addition to milk as part of a progressively varied diet when infants are six months old. http://www.healthystart.nhs.uk/

It is a means tested voucher scheme for pregnant women and families with children under four. If these women are in receipt of certain means tested benefits then they are eligible for vouchers to be spent on milk, infant formula milk, fruit and vegetables. They also receive free vitamins. All mothers under 18 are eligible for the scheme. Currently, vouchers worth £3.10 per week are given to eligible women; mothers with a child aged under one receive £6.10. The amounts are reviewed annually and have not changed since 2006. These can be spent in neighbourhood shops and pharmacies. A

health professional signs the application form confirming the pregnancy (or child under four) and that the applicants have received health advice. The voucher scheme was rolled out to all the UK in 2006 as a replacement to the Welfare Food Scheme.

The requirement for a health professional to countersign the application means there has been an opportunity for health promotion. The mother has been in contact with a health professional and has been offered appropriate health, nutrition and lifestyle information.

8. Give a brief explanation of the methods proposed

Secondary analysis of existing data
The IFS data are available for download from the UK Data Service and are anonymised.

The GUS data provided by ScotCen are anonymised. There is consent from 91% of GUS participants to link their survey data to obstetric records (SMR02), child hospitalisations (SMR01), A&E attendance, child immunisation records, child health surveillance records and dental inspection records (see Appendix 1). The linked data provided by ISD will be anonymised so the research team cannot identify individuals. Data will be held in a secure environment subject to ISD data confidentiality policies (http://www.isdscotland.org/About-ISD/Confidentiality/).

Qualitative interview study
This study starts in 2015, when children in GUS will be 5 years old. The HSV is in place until the child is 4. Mothers from GUS may have difficulty recalling their thought processes from up to 5 years previously. We therefore propose to complement interviews with GUS mothers with interviews with mothers who are current claimers of HSV and currently eligible for HSV but who do not claim. We will identify them from GP practices in Glasgow in datazones in the 15% most deprived areas by SIMD.

The 20 women purposively sampled from GUS will be sent an information leaflet and letter inviting them to take part in the semi-structured interviews. A follow-up telephone call will be made to get their response. For those who decline other GUS participants with similar characteristics will be contacted. The 20 women currently claiming/not claiming HSV will be purposively sampled from health visitor contacts at GP surgeries and parent groups in deprived areas of Glasgow. Information leaflets will be given to these groups inviting them to take part in the semi-structured interviews. We recognise the importance of face-to-face contact with potential respondents and therefore the researcher will visit the surgeries and groups on a regular basis. This will ensure the potential participants are fully informed of the study before agreeing to participate. Once the women have agreed to participate, an appointment for interview will be made. A reminder telephone call will be made in the week prior to the interview. The participating women will be offered a £20 voucher in recognition of their time spent being interviewed.

Interviews will be audio recorded using an encrypted digital recording device. Recordings will be sent anonymised to the transcribing service. Those involved are subject to MRC/CSO Social and Public Health Sciences Unit data confidentiality policies. Data will be transferred and held in a secure environment subject to MRC/CSO Social and Public Health Sciences Unit data sharing policies.

9. Proposed outcome measures

The outcomes relate to the four aims of the Healthy Start Voucher scheme (HSV aim):

1) to improve the nutrition of pregnant women;
2) to increase fruit and vegetable intake;
3) to initiate and maintain breastfeeding; and

4) to introduce foods in addition to milk as part of a progressively varied diet when infants are six months old.

The outcome measures fall into four categories: child weight and body size; child morbidity; infant feeding; and maternal health. They are available from three different sources, listed below and indicated in the list of measures.

1) Growing Up in Scotland survey (GUS)
2) Growing Up in Scotland survey linked to routine data sources (GUS-LK)
3) Infant Feeding Survey (IFS)

Primary Outcomes

Although the intervention is relatively simple its aims are multiple and complex. We propose to have two primary outcome measures one relating to the mother during pregnancy and one relating to the child in early infancy. These are important periods of risk and measure different but important aspects of public health.

1) Pregnancy: any vitamin use in pregnancy (HSV aim 1), dataset GUS, IFS
2) Early infancy: breast feeding initiation and duration (HSV aim 3), dataset GUS, IFS

Vitamin use during pregnancy is aiming to create a healthy uterine environment which is important for birth outcomes. An increase in vitamin use is one of the aims of the HSV. In early infancy, breast feeding is beneficial for many aspects of child health and morbidity [30]. An increase in breast feeding rates and duration is one of the aims of the HSV. Women from low income families, low social class and teenage mothers have lower rates of breastfeeding and vitamin use in pregnancy than other groups in the population. Providing health advice along with vouchers to use for a healthy diet (including milk and fruit and vegetables) should increase knowledge of the benefits of good maternal nutrition, reduce financial barriers to a more nutritious diet and, therefore, increased vitamin use.

HSV replaced the WFS which only provided milk tokens for liquid and infant formula milk. There was therefore no incentive to breastfeed since if the mother was breastfeeding she could only spend the money on liquid milk. HSV has broadened the scope of the vouchers to be used for fruit and vegetables as well as liquid and infant formula milk, so that mothers who choose to breastfeed are able to spend the vouchers on something other than milk. However there is still a risk that the option of free formula milk will disincentivise breast feeding. Conversely, the exposure to health advice associated with HSV could encourage higher rates of breast feeding. Thus comparing breast feeding rates between those who do and do not take up the vouchers is vital mainly to exclude the possibility that HSV is actually discouraging breast feeding.

Secondary outcomes

We propose several secondary outcomes.

1) Child weight and body size
    a. Birthweight (HSV aim 1), dataset GUS, GUS-LK, IFS
    b. Low birthweight (HSV aim 1), dataset GUS, GUS-LK, IFS
    c. Height at 3 years (HSV aim 2), dataset GUS
    d. Weight at 3 years (HSV aim 2), dataset GUS
    e. Overweight & obese 3 years (HSV aim 2), dataset GUS
    f. Weight gain (trajectory) (HSV aim 2), dataset GUS

2) Child morbidity
    a. Pre-term birth (HSV aim 1), dataset GUS-LK, IFS
    b. Gestational age (HSV aim 1), dataset GUS-LK, IFS
    c. Morbidity in 1st year (HSV aim 2,3), dataset GUS-LK, IFS
    d. Morbidity up to 3 years (HSV aim 2,3), dataset GUS-LK

3) Infant and child feeding
    a. Use of formula milk (HSV aim 3), dataset GUS, IFS
    b. Use of cow's milk before 1 year (HSV aim 4), dataset IFS
    c. Age at introduction of solids (HSV aim 4), dataset GUS, IFS
    d. Fruit intake at 3 years (HSV aim 2), dataset GUS
    e. Vegetable intake at 3 years (HSV aim 2), dataset GUS

4) Maternal health
    a. health problems during pregnancy (HSV aim 1), dataset GUS, GUS-LK, IFS
    b. weight gain in pregnancy (HSV aim 1), dataset GUS-LK
    c. Current health (HSV aim 2), dataset GUS
    d. Smoking (HSV aim 1), dataset GUS
    e. Alcohol use (HSV aim 1), dataset GUS

Confounding variables
In order for greater comparability between the studies, identical/harmonised variables from IFS and GUS will be used. The variables are described below.

The following groups have been identified as having more adverse birth outcomes and we will analyse the effect of HSV for them: those living in the most deprived areas, those in the lowest social classes, lone mothers, primiparous women, teen mothers and those in the lowest education group. We are also interested in ethnic group of the mother as it is an important factor for our outcomes [31]. We will therefore, within the constraints of the data and disclosure issues, include ethnicity as a covariate in the analyses. Most of the research questions/secondary outcomes will use GUS and GUS/linked data to answer them. Ethnicity in GUS reflects the ethnic composition of Scotland and comprises 95% white and 5% non-white; due to the small sample sizes of non-white groups, it is not possible to break the non-white group into more refined ethnic groups. The ethnicity in IFS reflects the ethnic composition of GB (England, Scotland and Wales) and is 82% white. Ethnicity was not asked in the Northern Ireland sample.

Secondary analysis of existing data – GUS and GUS/linked data
When analysing GUS data and GUS/linked data, the Scottish Index of Multiple Deprivation (SIMD) will be used. The SIMD combines information across six domains: income; employment; health; education; housing; and geographical access. It provides a comprehensive picture of material deprivation in small areas within Scotland. The index ranks 6505 areas from the most deprived to the least deprived and measures the degree of deprivation of an area relative to that of other areas. The areas employed by the SIMD are data zones and are small: the 6505 data zones have a mean population of 780 people (approximately half the size of a lower super output area in England). The reason for employing small area geography at this scale is to permit identification of relatively small pockets of deprivation, and minimise misclassification. The health domain for the SIMD includes an indicator of the proportion of live singleton births of low birth weight. This project is measuring birthweight and low birthweight and so it would not be appropriate to use the health domain or the composite index which includes the health domain. The income domain will therefore be used to assess inequalities at the area level. The income domain contains six indicators relating to receipt of means tested benefits and tax credits. Area based deprivation is only available for GUS not for the IFS.

For individual level assessment of socioeconomic position and inequalities in GUS we will use:
Social class – NS-SEC of mother; father; household
Household income
Educational status – education attainment of mother
Family type - single mother/lone parent, couple family

Primiparous – first born, other children
Age of mother at birth of child – Age <20, 20-24, 25-29, 30-34, 35-39, 40+
Ethnic Group - White; other ethnic background
Urban/Rural Classification – Large urban; Other urban; Small, accessible towns; Small remote towns; Accessible rural; Remote rural

Secondary analysis of existing data – IFS
Social class – NS-SEC of mother - 1: Managerial & professional; 2: Intermediate occupations; 3: Routine & manual occupations; 4: Never worked; 5: Not classified
Educational status – age mother left full-time education – 16 or under, 17-18, over 18.
Single mother
Primiparous – first birth, second or later birth
Age of mother – Age <20, 20-24, 25-29, 30-34, 35+
Ethnic Group - 1: White; 2: Mixed; 3: Asian or Asian British; 4: Black or Black British; 5: Chinese or other ethnic group

Qualitative interview study
To understand better the trial outcomes, and to understand the process of claiming and using the vouchers, we propose to gather qualitative data on reasons for uptake and non-uptake of Healthy Start Vouchers and what the vouchers are spent on.

10. Assessment and follow up

10.1 Assessment of efficacy/effectiveness

The main assessment uses pre-existing survey data, linked to routine health data. There are no issues of recruitment and retention to consider. Primary and secondary outcomes have been collected either in the surveys (Growing up in Scotland and Infant Feeding Survey) or in the routine health record data that are to be linked to Growing up in Scotland.

Both GUS and IFS are subject to non-response and sample attrition. In GUS, of all the families identified ahead of sweep 1 (age 10 months), 65% participated. At sweep 2 (age 3) 82% of those who participated at sweep 1 were achieved. There are survey weights which adjust for the resulting bias in the sample. In IFS, the response rate to each survey was: survey 1 (age 6 weeks) 51%, survey 2 (age 4-6 months) 82% and survey 3 (8-10 months) 86%.

The additional data collection to determine reasons for both take-up and non-take-up will be hour-long, taped interviews. They will be interviewed once and we do not propose to follow these mothers. The interviews will be recorded on an encrypted recorder, anonymised and transcribed verbatim. The transcripts will be checked against the original recording before analysis starts. Semi-structured interviews will be used to guide the women through their experiences of HSV.

10.2 Assessment of harms

It is possible that harm may have occurred due to freeing up income from the use of the vouchers. Pregnant women and mothers may have used this freed up income to purchase items detrimental to birth outcomes. We are examining how the intervention group differed; vitamin use, breast-feeding and infant weight could have reduced or increased. We will carry out 2-sided hypothesis tests to ensure that we are able to detect such potentially harmful effects.

11. Proposed sample size

This project is an analysis of existing secondary data. As such the sample size is fixed. We can, however, give an indication of the likely effect size that can be detected given the sample size, with significance level of 95% and power 80%.

GUS has a sample size of 6127, with 1350 (22%) identified as claiming HSV and 2336 (38%) identified as eligible but not claiming. GUS is a clustered sample of 199 datazones with approximately 30 respondents per cluster. Assuming an intraclass correlation coefficient of 0.01 and 63% breast feeding initiation, 80% power and 95% significance level, the sample size of GUS will be able to detect a 5% difference (ie 68% breast feeding initiation).

12. Analysis

Statistical Analysis
The group of women who are eligible for HSV are also those who are less likely to breast feed and be at risk of more adverse outcomes, even within this eligible group there will be variation in breast feeding rates. One difficulty is how to control for these confounding characteristics and also be able to detect an effect of HSV given all these other influences on breastfeeding. A strength of this proposal is we have many background characteristics that are related to both adverse outcomes and the likelihood of being low-income and therefore eligible for HSV. We can adjust for these influences in our analyses. The propensity score matching analysis will give the probability that an eligible person will have received HSV given the characteristics associated with up-take of HSV, and probabilities for the control group. Therefore the two comparison groups should be balanced in terms of the factors associated with up-take of HSV, and any effect of HSV should be unbiased.

For the regression discontinuity analysis, we will follow the approach outlined by Imbens and Lemieux [18]. Linear regression will be used when the outcome is continuous and logistic regression when the outcome is dichotomous. The GUS data are clustered and so multilevel modelling will be used for these data. All analyses will be adjusted for appropriate confounders including maternal obstetric characteristics, maternal and family social status measures and area deprivation. Regressions with polynomials will be used to assess the non-linearity of the relationship between outcomes and HSV. Local regressions will be estimated for both the intervention and comparison groups and the difference between the two estimates will be the effect of HSV.

We anticipate item non-response for some outcomes and explanatory variables. We will use multiple imputation to account for missing data and all analyses will compare the results of analyses of complete cases and multiple imputation. Imputed models will be constructed such that they contain as many relevant variables as possible. The more variables that are used the greater the amount of information available on which estimations are made. We will use multiple imputation by chained equations to complete the missing observations in the data set. Multiple imputation by chained equations uses a series of univariate analyses to predict missing values. For each variable to be imputed, imputed values are drawn from a conditional distribution based on univariate regression models. This process is repeated multiple times using previously estimated values and should converge to a stable multivariate solution. It is difficult to identify in advance the number of multiple imputed datasets we will need to construct but it is likely to be between 5 and 10. We will then analyse these datasets identically and combine the results to get the estimates and standard errors for the multiple imputed data. These results will be compared to the complete case analysis results. The missing data mechanism is likely to be missing completely at random (MCAR) or missing at random (MAR).

A further consideration for missing data is lack of consent to linkage of GUS to the routinely collected datasets. This is very low; only 9% of GUS respondents did not consent to have their survey data linked to routine data. We will compare the characteristics of consenters and non-

consenters on key variables (primary and secondary outcomes; social class, household income, educational status, family, age of mother, ethnic group, urban/rural classification and SIMD quintile) to ascertain any systematic differences between the groups. If there are any differences we will conduct a sensitivity analysis using inverse probability weighting to account for these differences.

It is of interest to determine what the vouchers were used to purchase; liquid milk, infant formula milk or fresh fruit and vegetables. Using questions from the surveys, we will report what the vouchers were used to purchase. We will do this for the GUS and IFS survey participants who were eligible and claimed HSV.

The data used for this project come from different existing sources using different methods for collection and different questions. IFS is a self-complete questionnaire. Mothers are invited to take part via a letter and can complete the questionnaire either online or on paper and then mail it back. GUS is a face-to-face interview with a researcher. Mothers are invited to take part via a letter and an interview time is agreed. The questionnaire is completed using computer-assisted personal interviewing; some parts of the questionnaire may be self-completed during the interview process. These different methods of data collection and differences in questions may cause bias in the results.

We will compare results from GUS and IFS for those exposed (Group 1) vs eligible but not exposed (Group 2). If any differences are found between GUS and IFS, they could reflect the differences in survey methodology rather than real differences between the survey populations (Scotland for GUS, UK for IFS). We will conduct a sensitivity analysis to account for the different data sources. This will comprise 2 parts, within the limitations of the data due to sample size.

1) Using only the IFS data, we will compare results for the Scotland sample to England, Wales and Northern Ireland
2) We will compare GUS to the Scotland sample of the IFS

We will do this for the primary outcomes and all secondary outcomes that are available in both surveys. Although we will have limited power formally to detect differences using the above comparisons, the results may indicate whether any observed differences reflect population differences or are artefacts of the different survey methodologies used.

Some models will contain small numbers but we will report the results of all pre-specified outcomes and not just those that reach statistical significance to avoid false negatives. The analysis will involve conducting many tests, which will not be independent of each other. Rather than adjusting confidence intervals or p-values to account for this we will present the results of all analyses and caution the user regarding the interpretation of the results.

Cost effectiveness analysis

The costs of providing and administering the HSV (the 'intervention' costs) will be identified alongside potential cost impacts (costs incurred as well as cost savings). Health and social care resource use will be identified from the two surveys. Firstly, from the 2010 Infant feeding survey the following resources will be identified and measured: Admission to special care baby; Type of delivery; Child overnight stay in hospital (after discharge for birth); Child seen by a health visitor; Child taken to health clinic or GP (including frequency of visits) ;Attendance at breastfeeding clinic/support groups. Secondly, from the Growing up in Scotland Birth Cohort 2 survey the following resources will be identified and measured: Frequency of health visitor appointments in 1st 3 months; attendance at Triple P, Incredible Years, Bricks & Mortar, Mellow Parenting, PEEP parent education; usage of: care Link website/phoneline, ParentLine Scotland, ChildSmile website, Play Talk Read website; number of health problems they contacted health professional for; number of hospital admissions. In addition this survey has linked data with the following resource use data: hospital admissions (SMR01); Health Visitor reports; Child immunisation records; Dental inspections and A&E attendance. Resource use identified and measured within these surveys will be valued

using readily available sources of unit cost information including where relevant: NHS Reference costs [32]; Scottish Health Service costs [33]; Unit costs of health and social care [34]. Additional unit costs for items such as parenting service (Triple P etc) will be estimated via direct contact with the service provider or literature searching of previous economic evaluations in these areas. The outcome for the economic evaluation will mirror the main study outcomes hence the economic evaluation will take the form of an incremental cost-effectiveness analysis with the incremental costs of the HSV intervention being compared with the incremental effectiveness as follows: Incremental cost per increased vitamin use in pregnancy; Incremental cost per increased percentage of breast feeding duration.

The economic analysis will follow the statistical methods from the main statistical analysis with explicit consideration of bias occurring with observational data. The economic analysis will comprise a secondary analysis of the two surveys using a multiple analytical approach including propensity matching and regression discontinuity [20]. In the regression analysis, the total cost variable will be estimated net of any cost savings identified. An annual population health economic discount rate of 1.5% will be applied to the longer term costs and outcomes [35]. The results of the cost-effectiveness analysis will be reported using a cost-effectiveness plane and cost-effectiveness acceptability curves [36]. Probabilistic sensitivity analysis will be undertaken to characterise uncertainty in the parameter estimates, and estimate confidence limits around the cost and effectiveness outcomes.

Given the limitations of narrow cost-effectiveness analysis results from a decision makers perspective, the regression results will be combined with evidence from a systematic review of the literature linking short-term outcomes with longer term outcomes to produce a long term cost-effectiveness model. Specifically, the primary and secondary outcomes identified in the analysis will be incorporated into a decision analytic model and combined with unit costs of events associated with these outcomes to produce a longer term cost-effectiveness estimate. There is a vast literature on the economic benefits of breastfeeding which will be used within the economic model [37-40]. However given that such long term impacts are likely to be reliant on untestable assumptions [13] the decision model will comprise a detailed sensitivity analysis to explore how cost-effectiveness will vary within all realistic ranges of costs and outcomes.

An economic logic model will be developed to systematically identify all relevant costs and cost savings as well as to identify potential longer term cost impacts.

All outcomes will be presented using a ‘balance sheet’ approach so that we can report all consequences and their associated uncertainty alongside the costs/cost savings arising. Such an approach will not only provide a more comprehensive summary of the balance of costs and outcomes but will also identify the table of parameters for the longer term decision analytic model.

Qualitative analysis
The optimum sample size for the semi-structured interviews is 40 (see above). This is relatively large for a qualitative study but should be feasible within the 18 month period. Interviews will be transcribed, coded according to prior and emergent themes probably using software such as NVIVO, summarised systematically by charting according to key themes, and emerging hypotheses tested according to all the relevant data. Particular foci will be the processes involved in the take-up, non take-up or discontinuation of HSV, the experience of using HSV and how the vouchers are used. Responses will be compared between the four groups of women: 1) GUS claimers, 2) GUS eligible non-claimers, 3) current claimers, 4) current eligible non-claimers.

13. Ethical arrangements

Secondary analysis of existing data

Ethical approval is not required as there is no primary data collection. The data for both the IFS and GUS have already been collected and are available for use for research purposes. The linkage and release of the GUS data with the routinely collected data for research purposes are subject to agreement from the Privacy Advisory Committee at NHS National Services Scotland. The data collection, storage and release for research purposes are subject to strict Information Services Division protocols governing privacy, confidentiality and disclosure of data (http://www.isdscotland.org/About-ISD/Confidentiality/). We will submit our application to link the GUS data to the routinely collected data to the Privacy Advisory Committee (http://www.nhsnss.org/pages/corporate/privacy_advisory_committee.php). At the time of analysis the body responsible for the information governance will be the Farr Institute (http://www.farrinstitute.org/centre/Scotland/24_Innovative-Governance.html) and we will adhere to their policies.

Qualitative interview study
Participants in GUS have already given consent to be contacted for research purposes. Only those who have agreed to further contact for research purposes will be approached. We will submit our application for ethical approval to College of Social Sciences Ethics Committee for non-clinical research involving Human Subjects. This Committee complies with the Economic and Social Research Council's research ethics framework.

14. Research Governance

The University of Glasgow will be the nominated sponsor of the research. Access to the data will be restricted to the investigators on this study.

We will have a steering committee comprising (at least): a chair from the MRC/CSO Social and Public Health Sciences Unit, a representative from an NHS Health Board who was responsible for the delivery of the HSV (John O'Dowd), a community mid-wife/health visitor, a representative from Child Poverty Action Group Scotland (Mark Willis) and the programme director of the Child and Maternal Health Intelligence Network at Public Health England (Helen Duncan). We have requested permission from Scottish Government (the funders of GUS) to invite 2 representatives from the GUS sample – one who claims HSV and one of is eligible but does not claim to be fully involved in the Steering Group. The steering committee will consider opportunities for dissemination beyond academic journals and conferences. They will also advise on reasons for non take up of the vouchers among eligible mothers to inform the propensity score matching.

The project team will meet face-to-face or via teleconference at least every three months. For the quantitative analyses Dundas, Leyland, and the statistician/epidemiologist (tba) will meet at least monthly. For the qualitative analyses Dundas, Wight, and the researcher (tba) will meet monthly. For the cost-effectiveness analyses McIntosh and the economist (tba) will meet at least monthly.

15. Project timetable and milestones

The following tasks will be carried out before the start date of June 2015:
Jan 15 - PAC application submitted for linkage
May 15 - Recruitment of RA/Epidemiologist
May 15 - Recruitment of RA (qualitative interview study)

Date	**Milestone**
01 Jun 15	**Project Starts**
Jul 15	Prepare GUS and IFS data for analysis

Sep 15	Conduct interviews
Oct 15	Receive linked data
Nov 15	Clean, check and prepare data for analysis
Dec 16	Qualitative data analyses completed
Dec 16	Statistical data analyses completed
Dec 16	Cost effectiveness analysis completed
May 17	Minimum linked GUS dataset available to approved researchers from ADLS/Farr Institute/ISD
May 17	Disseminate findings via conferences and papers
May 17	Write final report
31 May 17	**Project Ends**

16. Expertise

Ruth Dundas is a statistician with expertise in researching health inequalities using Scottish routine data. She will be responsible for the direct supervision of the epidemiologist employed on the study, oversee the project, contribute to the study design, analysis and interpretation of the results. Ruth will also liaise with ISD for the data linkage of GUS to ISD held health data.

Alastair Leyland is a statistician with experience of working with Scottish routine data, researching health inequalities, the use of multilevel models in health research. He will act as a mentor to the PI (Dundas) and will contribute to project oversight and design, analysis and interpretation.

Peter Craig has expertise in evaluating the health effects of social interventions and will contribute to the study design and interpretation of the results. He has worked in both the Department of Social Security (now Work and Pensions) and the Scottish Government Health and Social Care Directorates, and his close links to policy will aid in dissemination.

Emma McIntosh is a health economist with expertise in the methods of economic evaluation and evaluating population health interventions including early years economic evaluations. Emma will design and oversee the cost-effectiveness analysis contribute to the interpretation of the economic evaluation results and writing up of economic evaluation results.

Alison Parkes is a researcher with expertise in analysis of GUS study. She will contribute to the study design, analysis and interpretation of the results.

Daniel Wight has expertise in qualitative study methodology, early years interventions, and development and evaluation of interventions. He will contribute to the study design, analysis and interpretation of the results and will oversee the qualitative interview study.

Charlotte Wright is a Professor of Community Child Health and has expertise in paediatric epidemiology, infant nutrition and feeding. She will contribute to the study design and interpretation of the results.

Paul Bradshaw, as Project Director of the Growing up in Scotland Study has expertise in the design and analysis of GUS data. He will contribute to the study design and interpretation of the results and liaise with ISD to facilitate the data linkage of GUS to ISD held health data.

17. Partner Collaboration

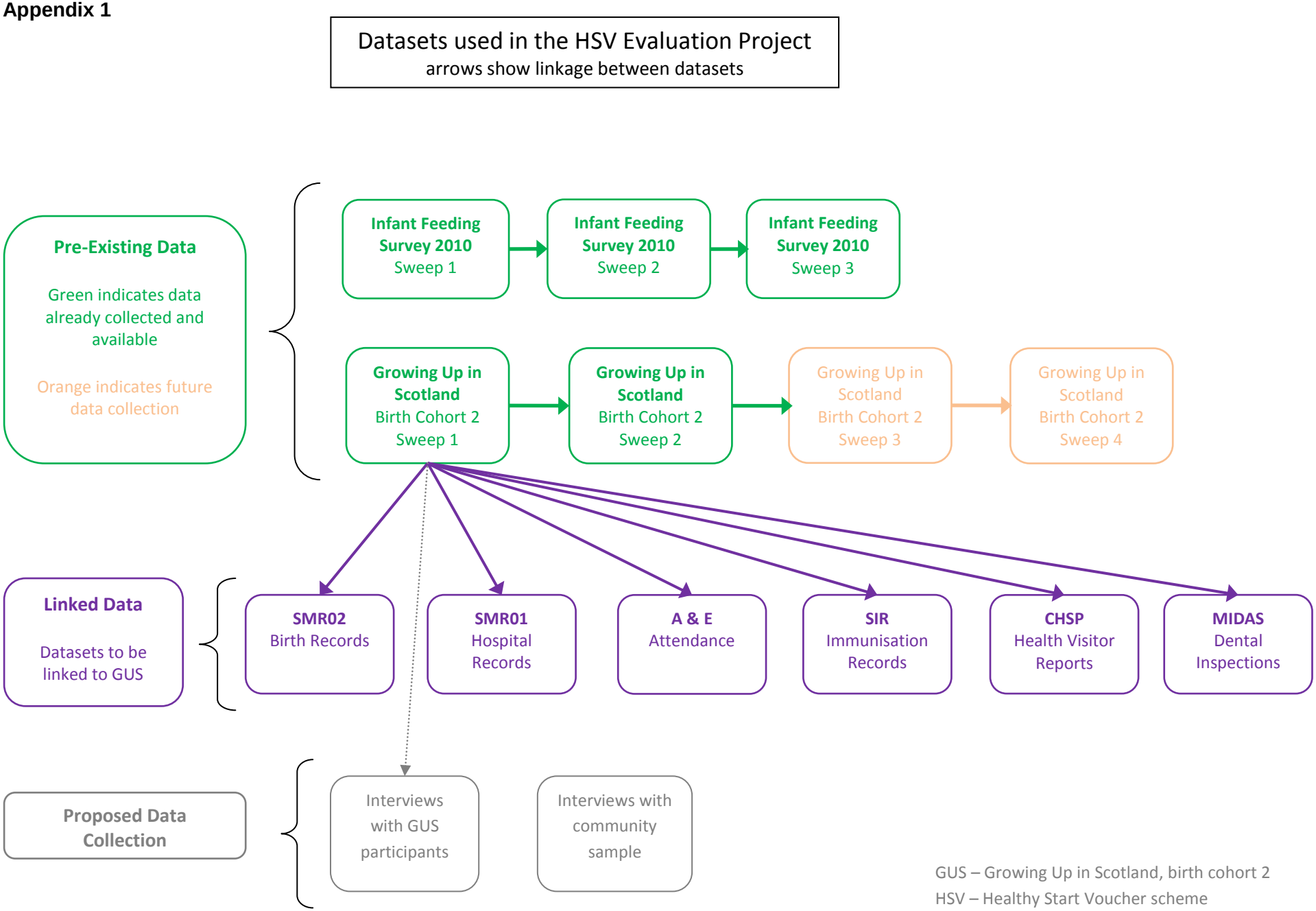
Through our steering committee we will have partner collaborations with NHS Scotland, the Growing Up in Scotland survey, Child Poverty Action Group Scotland and Public Health England.

References

1. Barker, D.J.P., *Fetal and infant origins of adult disease*. 1992: BMJ Books.
2. Skinner, J.D., et al., *Children's Food Preferences: A Longitudinal Analysis.* Journal of the American Dietetic Association, 2002. **102**(11): p. 1638-1647.
3. Skinner, J.D., et al., *Do Food-Related Experiences in the First 2 Years of Life Predict Dietary Variety in School-Aged Children?* Journal of Nutrition Education and Behavior, 2002. **34**(6): p. 310-315.
4. Mishra, G., et al., *The impact of inter-generational social and regional circumstances on dietary intake patterns of British adults: results from the 1946 British Birth Cohort.* Public Health Nutrition, 2004. **7**(06): p. 737-744.
5. Tseng, M., *Social circumstances and dietary intake.* Public Health Nutrition, 2004. **7**(06): p. 695-696.
6. Department of Health. *http://www.healthystart.nhs.uk/*.
7. Ford, F.A., et al., *Effect of the introduction of 'Healthy Start' on dietary behaviour during and after pregnancy: early results from the 'before and after' Sheffield study.* British Journal of Nutrition, 2009. **101**(12): p. 1828-1836.
8. Mouratidou, T., et al., *Are the benefits of the 'healthy start' food support scheme sustained at three months postpartum? Results from the Sheffield 'before and after' study.* Maternal & Child Nutrition, 2010. **6**(7).
9. McFadden, A., et al., *Can food vouchers improve nutrition and reduce health inequalities in low-income mothers and young children: a multi-method evaluation of the experiences of beneficiaries and practitioners of the Healthy Start programme in England.* BMC Public Health, 2014. **14**: p. 148.
10. McFadden, A., et al., *Healthy Start, UNDERSTANDING THE USE OF VOUCHERS AND VITAMINS*. 2013.
11. McAndrew, F., et al., *Infant Feeding Survey 2010*. 2012.
12. Hansard HC W, *25 Jun 2014 : Column 243W*. 2014.
13. Craig, P., et al., *Using natural experiments to evaluate population health interventions: new Medical Research Council guidance.* Journal of Epidemiology and Community Health, 2012.
14. Scottish Government, *Early Years Framework. www.scotland.gov.uk/About/Performance*. 2012.
15. Annual Report of the Chief Medical Officer 2012, *Our Children Deserve Better: Prevention Pays*. 2013, Department of Health.
16. Department of Health, *Reform of the Welfare Food Scheme, London*. 2002.
17. Dyson, L., et al., *Approaches to evaluating Healthy Start – a scoping review* 2007, Mother and Infant Research Unit, Public Health Research Consortium: York.
18. Imbens, G.W. and T. Lemieux, *Regression discontinuity designs: a guide to practice.* Journal of econometrics, 2008. **142**(2): p. 615-635.
19. Bradshaw, P., et al., *Growing Up in Scotland: Birth cohort 2 Results from the first year*. 2013.
20. Dunning, T., *Natural Experiments in the Social Sciences: A design-based approach.* 2012, Cambridge Cambridge University Press.
21. Dusheiko, M., et al., *The effect of budgets on doctor behaviour: evidence from a natural experiment. Discussion papers in economics.* . 2003, University of York: York.

22. Imbens, G.W. and J.M. Wooldridge, *Recent Developments in the Econometrics of Program Evaluation.* Journal of Economic Literature, 2009. **47**(1): p. 5-86.
23. Meyer, B.D., *Natural and Quasi-Experiments in Economics.* Journal of Business & Economic Statistics, 1995. **13**(2): p. 151-161.
24. Rosenzweig, M.R. and K.I. Wolpin, *Natural "Natural Experiments" in Economics.* Journal of Economic Literature, 2000. **38**(4): p. 827-874.
25. Angrist, J.D. and A.B. Keueger, *Does Compulsory School Attendance Affect Schooling and Earnings?* The Quarterly Journal of Economics, 1991. **106**(4): p. 979-1014.
26. Angrist, J.D. and V. Lavy, *Using Maimonides' Rule to Estimate the Effect of Class Size on Scholastic Achievement.* The Quarterly Journal of Economics, 1999. **114**(2): p. 533-575.
27. Blundell, R. and M. Costa Dias, *Alternative approaches to evaluation in empirical microeconomics.* 2002, Cemmap working paper.
28. Rovithis, D., *Do health economic evaluations using observational data provide reliable assessment of treatment effects?* Health Economics Review, 2013. **3**(1): p. 21.
29. Rosenbaum, P.R. and D.B. Rubin, *The Central Role of the Propensity Score in Observational Studies for Causal Effects.* Biometrika 1983. **70**(1): p. 41-55.
30. Hoddinott, P., D. Tappin, and C. Wright, *Clinical Review: Breast feeding.* BMJ, 2008. **336**: p. 881.
31. Bansal, N., et al., *Ethnicity and first birth: age, smoking, delivery, gestation, weight and feeding: Scottish health and ethnicity linkage study.* European Journal of Public Health, 2014.
32. NHS Reference costs, *New NHS reference costs. http://www.dh.gov.uk* 2014, Department of Health,.
33. ISD, *Scottish Health Service costs www.isdscotland.org.* 2014, ISD Scotland.
34. Curtis, L., *Unit Costs of Health and Social Care.* 2013, PSSRU, University of Kent at Canterbury: Canterbury.
35. National Institute for Health and Clinical Excellence (NICE), *Methods for the development of NICE Public health guidance (third edition).* . 2012.
36. Fenwick, E., B.J. O'Brien, and A. Briggs, *Cost-effectiveness acceptability curves – facts, fallacies and frequently asked questions.* Health Economics, 2004. **13**(5): p. 405-415.
37. Ball, T.M. and A.L. Wright, *Health Care Costs of Formula-feeding in the First Year of Life.* Pediatrics, 1999. **103**(Supplement 1): p. 870-876.
38. Bartick, M. and A. Reinhold, *The Burden of Suboptimal Breastfeeding in the United States: A Pediatric Cost Analysis.* Pediatrics, 2010. **125**(5): p. e1048-e1056.
39. Renfrew, M., et al., *Preventing disease and saving resources: the potential contribution of increasing breastfeeding rates in the UK.* 2012, UNICEF.
40. Weiner, J., *The Economic Benefits of breastfeeding: a review and analysis.* 2001, Food and Rural Economics Division, Economic Health Research, US Department of Agriculture: Washington DC.

Appendix 1


Datasets used in the HSV Evaluation Project
arrows show linkage between datasets
Pre-Existing Data
Green indicates data already collected and available
Orange indicates future data collection
Infant Feeding Survey 2010 Sweep 1
Infant Feeding Survey 2010 Sweep 2
Infant Feeding Survey 2010 Sweep 3
Growing Up in Scotland Birth Cohort 2 Sweep 1
Growing Up in Scotland Birth Cohort 2 Sweep 2
Growing Up in Scotland Birth Cohort 2 Sweep 3
Growing Up in Scotland Birth Cohort 2 Sweep 4
Linked Data
Datasets to be linked to GUS
SMR02 Birth Records
SMR01 Hospital Records
A & E Attendance
SIR Immunisation Records
CHSP Health Visitor Reports
MIDAS Dental Inspections
Proposed Data Collection
Interviews with GUS participants
Interviews with community sample
GUS – Growing Up in Scotland, birth cohort 2
HSV – Healthy Start Voucher scheme